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CENTER

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ITIC DIRECTOR

Mr. George Pararas-Carayannis will assume his new post as Director of the International Tsunami Information Center in Honolulu, Hawaii, as of October 1, 1974. Prior to accepting this position, Mr. Pararas-Carayannis served as an oceanographer with the U. S. Army Coastal Engineering Research Center at Fort Belvoir, Virginia. He also served as an oceanographer with the U. S. Army Engineer District in New York and with the National Ocean Survey in Honolulu, Hawaii.

TSUNAMI WORKSHOP - OCTOBER 13-16, 1974

The proposed Tsunami Workshop scheduled to be held at the Residential Conference Center of the University of California at Lake Arrowhead, California, from October 13 through 16, had to be postponed due to funding problems. Current plans are to hold the conference after the new year, either in late spring or early summer. Enquiries concerning the conference should be directed to Professor Fredric Raichlen of California Institute of Technology, Pasadena, California. It would be very much appreciated if the informal abstracts which many of the scientists have prepared for that Tsunami Workshop were to be made available for the ITIC Newsletter. This exchange of information will be very helpful in letting the tsunami research community become aware of each other's work on a timely basis. Editing of these informal abstracts (or papers) can be done by the ITIC staff so that no additional burden will be put on the researchers and so that they will fit into the limited space of the ITIC Newsletter.

JTRE TSUNAMI WORKSHOP PRESENTATIONS

Dr. Gaylord Miller, Director, Joint Tsunami Research Effort, located at the University of Hawaii, submitted the following to the ITIC for the Newsletter. These are examples of a paper and abstracts that were to be presented at the Workshop.

1. "Use of an Ionospheric Technique to Improve the Tsunami Warning Systems," by P. C. Yuen et al.

After the destructive tsunami generated in the Pacific Ocean by the 1946 Aleutian earthquake, the U. S. Coast and Geodetic Survey set up the Pacific Tsunami Warning System which presently consists of a network of seismographs and tide gauges linked by a radio and cable communication system. Whenever a major earthquake occurs with its epicenter within the Pacific Ocean, personnel at the tide stations are requested to monitor their gauges for evidence of tsunami wave action in their areas. These tide reports are then used with other information to determine whether a tsunami has been generated and whether a tsunami alert should be called.

There are inherent difficulties with this method. Decisions are based on information received from distant tide stations which may be near the epicenter of the earthquake and whose tide gauges and other equipment may have been damaged. The radiation pattern of a tsunami wave can be very directional and, because it is dependent on the direction and size of the earthquake's fault line, tide gauge readings at one station cannot be extrapolated directly to another location.

Personnel associated with the Warning System are usually faced with the difficult task of deciding whether to call a tsunami warning without having sufficient information upon which to base a sound decision. In the past this led to numerous warnings being called in order to insure the public's safety. However, the number of "false alarms" caused by this practice created such a skepticism that warnings were not heeded. In addition, the sounding of a tsunami warning causes a vast evacuation which can be expensive to merchants and restaurant owners, causes great inconvenience to others, and is a hazard to all because of the heavy traffic and alarmed atmosphere. Now, improved data are evaluated carefully so that warnings are called less frequently. However, the warning system needs to be made more reliable and self-sufficient.

Reliable tide reports from many widely-spaced stations are the best indicators at present for determining whether tsunamis have been generated, but these reports have frequently not been available during actual crises. However, there is another very desirable and important datum which can be used for early tsunami warning:

the earthquake's source mechanism. It has been shown statistically that tsunamis are associated with ocean-occurring dip-slip earthquakes, rather than with strike-slip types. Thus the determination of an earthquake's source mechanism would be a possible method of providing an early warning of destructive tsunami wave action. Many methods for source mechanism analysis have been developed but very few are applicable in the short time available between the detection of the earthquake and the decision to call a tsunami warning.

The first method to be developed for source mechanism analysis was the use of initial motions of the P-wave. For this method, data from about forty stations evenly distributed throughout the world are necessary, but even then the solution obtained may be ambiguous. Equally as important, the present world communication network does not permit this method to be utilized.

The S-wave method of analysis requires the knowledge of particle motion of S-waves at various recording stations throughout the world. This, in turn, requires seismograms from matched horizontal seismometers at these stations. This method is also not presently feasible because of the lack of a suitable network.

Surface waves have been used in source mechanism analysis. The method developed by Ben-Menahem requires digitizing of records and spectral analysis of the waves by high-speed computers. The time required for this method is of the order of days at its most efficient performance and sometimes the necessary seismograms are not usable because Rayleigh waves and Love waves appear together on the seismograms, making the analysis extremely difficult.

The method of surface wave analysis developed by Brune is sufficiently simple in operation that a solution could be obtained in the short time available during a tsunami alert. If the dispersive property of the earth between the epicenter and the seismic station is known, the initial phase of the earthquake can be derived from a good recording of a dispersed train of Rayleigh surface waves. Thus the determination of whether a vertical slippage of the earth's crust has taken place at the ocean bottom, and hence whether a tsunami may have been generated, can be obtained from an analysis of the long-period vertical component of the Rayleigh wave and the location of the earthquake's epicenter.

Since the Rayleigh wave travels with speeds of about 20 times that of the destructive tsunami and hence reaches points thousands of kilometers away, many hours before the tsunami, a method could be developed for a tsunami early warning system if the long-period component of the Rayleigh wave could be successfully detected, recorded, and analyzed quickly. For all large earthquakes, epicenters generally are located rapidly and with sufficient accuracy to determine whether they occurred on land or in the ocean.

Brune's method using long-period Rayleigh wave recordings is therefore a very promising possible solution to the tsunami prediction problem. However, reliable seismograms obtained quickly after a large earthquake are necessary for its successful utilization. The most obvious way of obtaining such recordings of the Rayleigh waves is to use an earth-coupled seismograph capable of recording ultra-long-period waves in a fashion suitable for rapid data reduction. Such a seismograph is theoretically possible but none so far has been perfected so as to be usable in routine observation.

Recently, personnel at the University of Hawaii discovered a novel method of obtaining the desired seismograms in a rapid but reliable manner: the ionospheric tsunami warning technique. This technique rests on the fact that while traveling outward from the epicenter along the earth's surface, the earthquake-produced Rayleigh waves generate atmospheric waves which propagate upward as waves of pressure and density variations. The amplitudes of these waves increase with height because of the exponential decrease in density. At ionospheric heights these variations in the density of the neutral atmosphere also produce variations in the density of the free electrons there. The HF radio Doppler sounding method is a very sensitive way of detecting these waves of electron density variations and producing recordings of them. It has been found that the electron density waves are closely correlated with the Rayleigh waves and this makes possible the rapid reproduction of accurate, uncontaminated Rayleigh wave recordings.

The ionospheric warning technique is basically a simple and inexpensive one. Figure 1 gives a schematic diagram of the ionospheric Doppler sounding method as used at Hawaii in a tsunami warning system. A frequency-stabilized transmitter sends an HF radio wave into the upper atmosphere where it is reflected from the ionosphere back to a ground-based receiver. At the receiving site the instantaneous frequency of the received wave is measured.

Any change in the ionosphere through which the wave passes, such as an increase or decrease in ionization at or below the point of reflection as might be caused by the atmospheric waves launched by Rayleigh waves, will cause a change in the phase of the signal between the transmitter and the receiver. This change is detected and recorded by the system instrumentation as a change in the instantaneously-received frequency. While special transmitters can be used, extremely stable signals are readily available from the transmissions of time-and-frequency-standard stations, such as WWV and WWVH, throughout the world.

The HF radio Doppler sounder is promising as a tsunami warning technique because it can produce accurate uncontaminated recordings of the Rayleigh waves which then can be analyzed to determine the likelihood that the earthquake was tsunamigenic. Figure 2 shows Doppler and seismogram data for the May 16, 1968 Japanese earthquake with similar time scales. Note the similarities of the two records.

The ionospheric technique also has the following advantages which are important for any practical, real-time warning system:

(1) Uncontaminated Rayleigh wave recordings are produced since the shear-type Love waves do not couple to the atmosphere as do the vertical-motion Rayleigh waves.

(2) Low-pass filtering is caused by the atmosphere's frequency-selective properties with respect to upward-traveling acoustic waves.

(3) Signal amplification occurs because of the exponentially decreasing atmospheric density with height.

(4) Rapid data recording and reduction can be achieved.

Figure 3 gives a simplified block diagram of the instrumentation. Figure 4 contains a block diagram of the 10-MHz Doppler receiver system; the 5-MHz Doppler system is similar. As shown, the 5-MHz circuits receive the frequency-stabilized transmissions and produce the proper Doppler frequencies at the outputs of the appropriate phase detectors. The Doppler frequency is converted to a dc voltage by means of a frequency meter, amplified, and than recorded on a paper chart recorder. This recording of the long-period seismic Rayleigh waves is then used in an earthquake source-mechanism analysis. The probability of a destructive tsunami is determined from the results of the analysis.

In summary, if after a major earthquake, little or no disturbance due to the surface Rayleigh waves is detected in the ionosphere at the appropriate time, then the earthquake did not have a large dip-slip component and no tsunami alert needs to be called. On the other hand, if Rayleigh-wave disturbances are detected and measured in the ionosphere using the ionospheric tsunami warning system and the epicenter is in the ocean, then it is possible that tsunami waves may have been generated. The numerical probability of such an occurrence and the possible range of tsunami wave action are being studied.

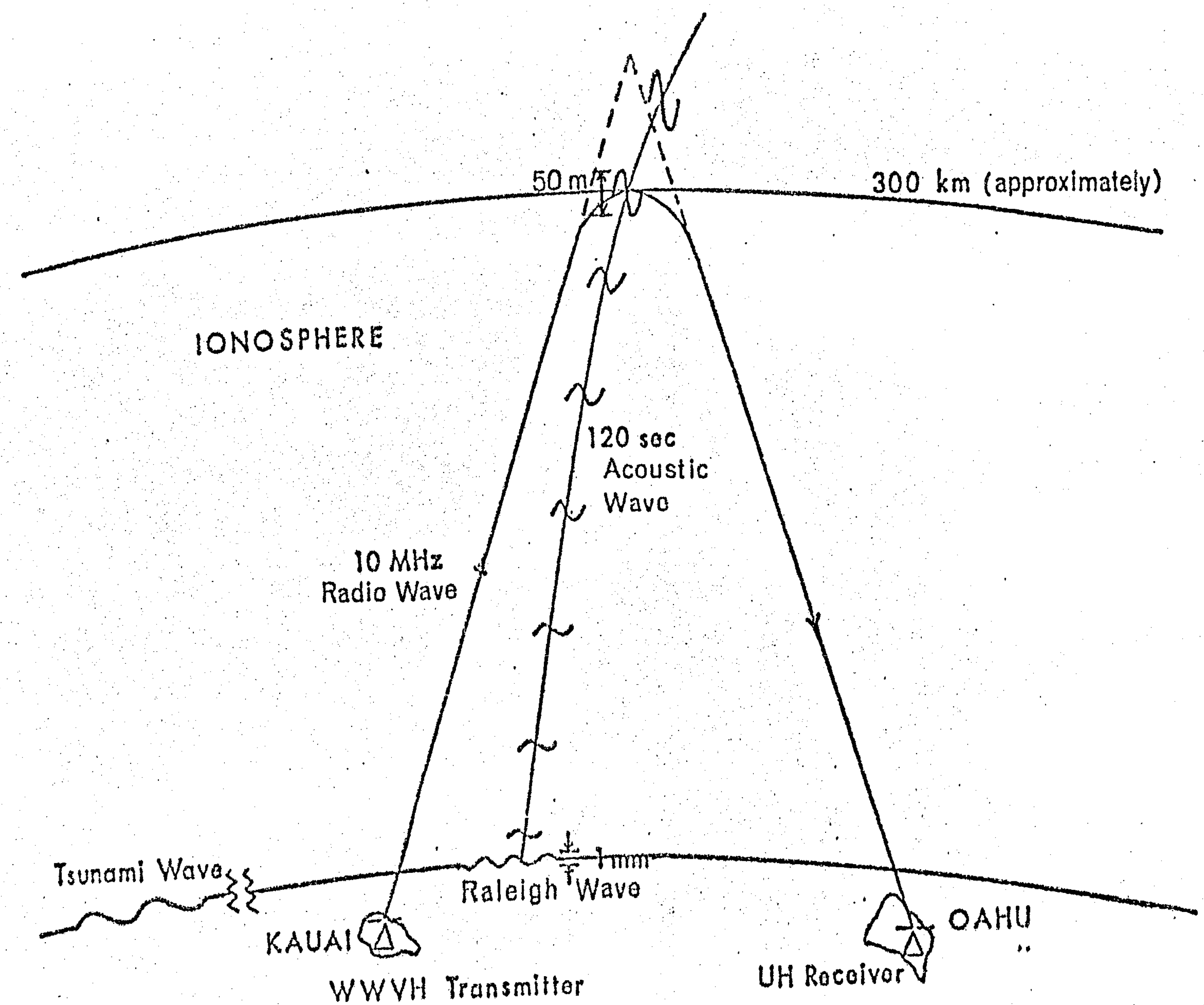

Fig. 1. Ionospheric Doppler Sounding.

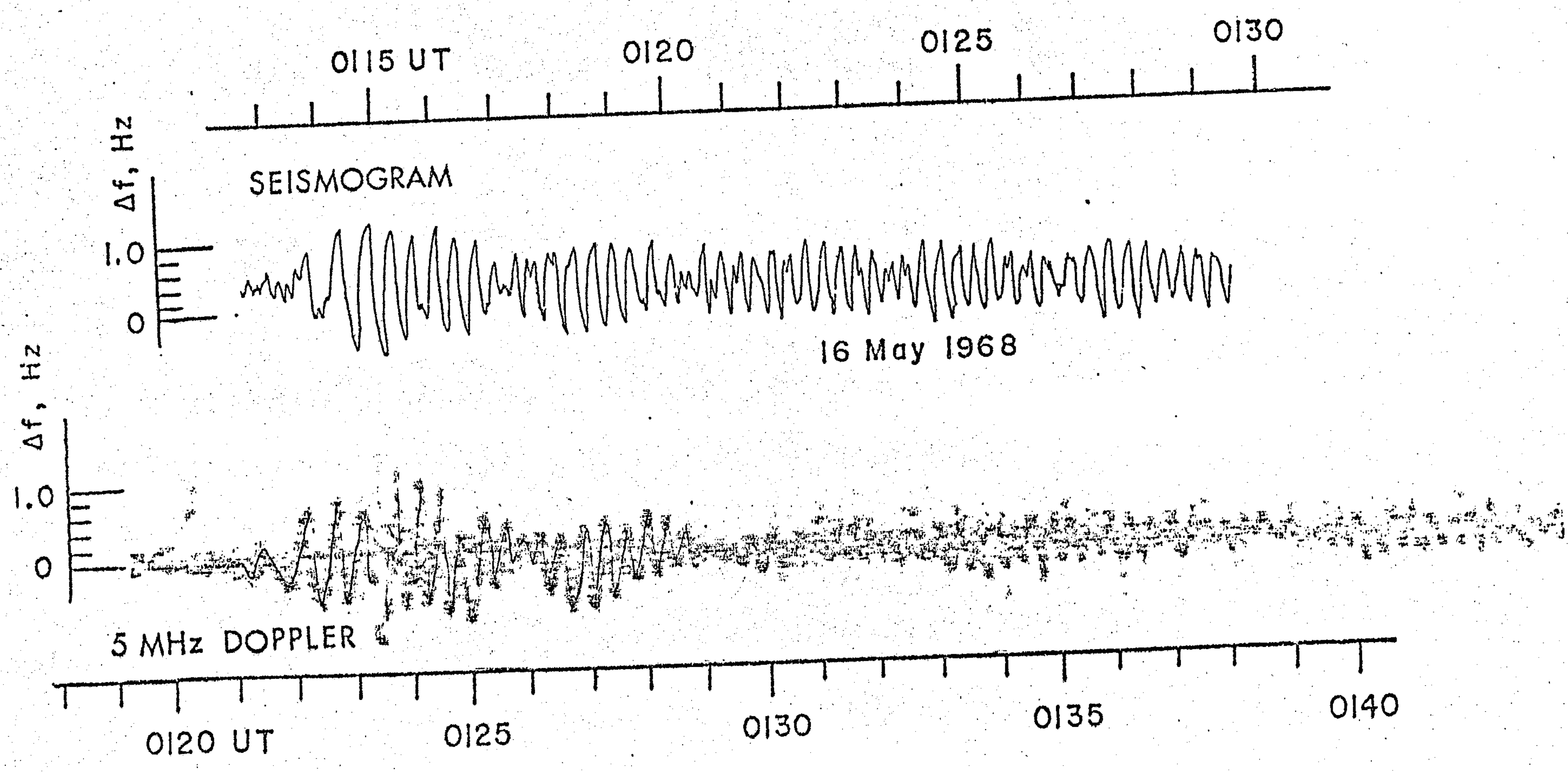

Fig. 2. Comparison of Doppler and Seismogram Data Obtained from the 16 May 1968 Japan Earthquake.

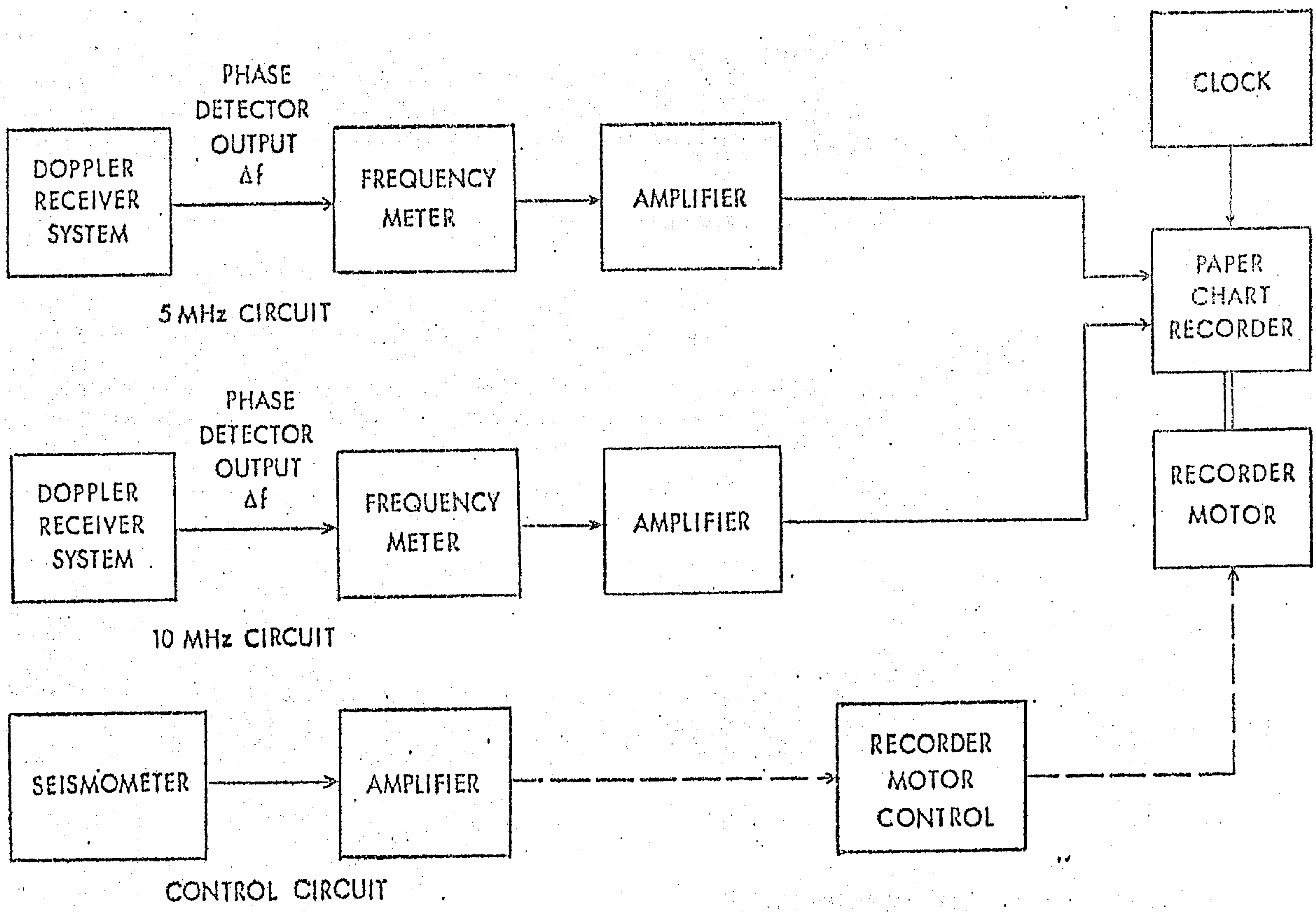

Fig. 3. Simplified Block Diagram of Instrumentation.

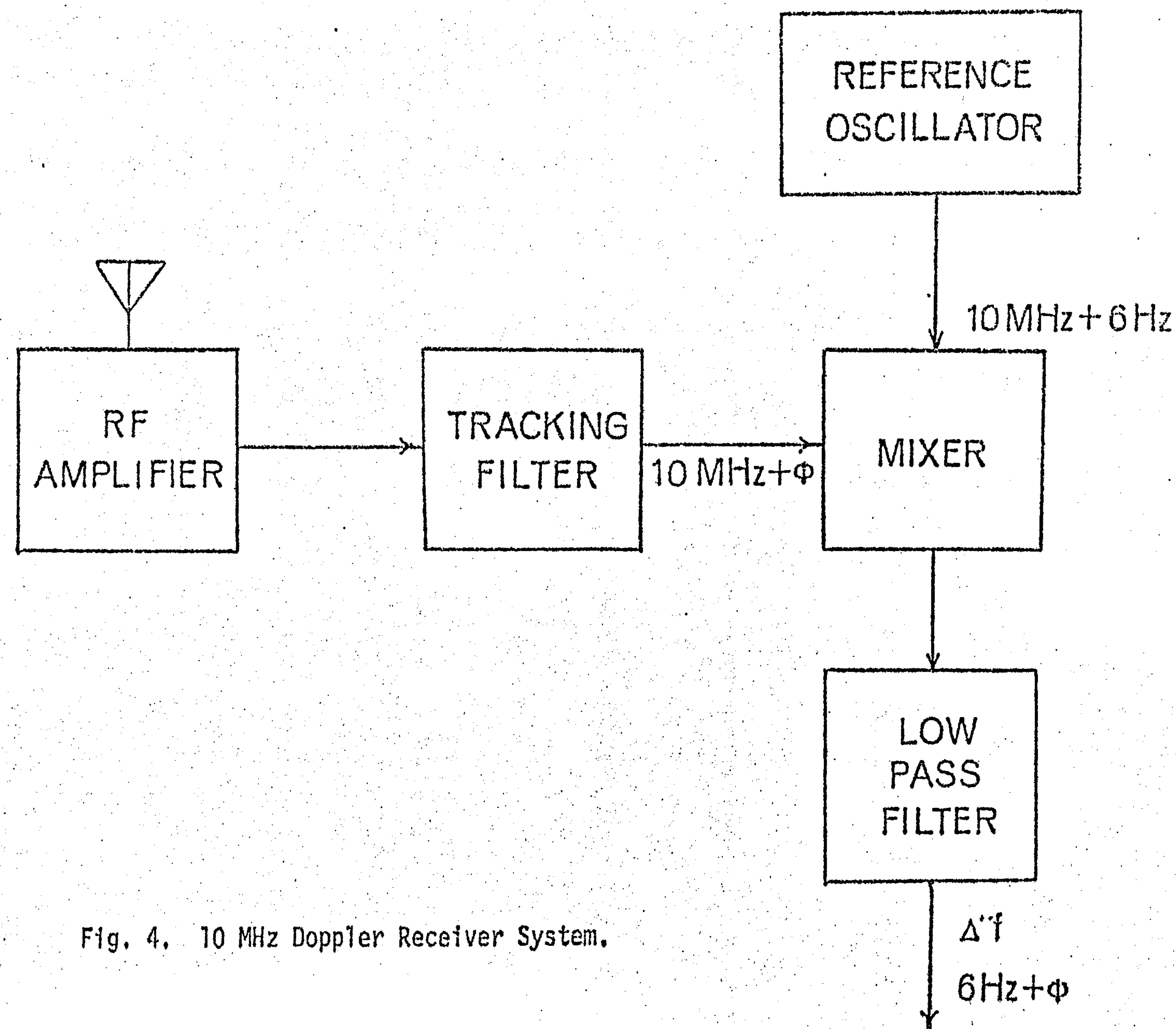

Fig. 4. 10 MHz Doppler Receiver System.

2. "Sea Floor Instrument for Tsunami Reporting," by G. R. Miller.

The first instrument unit was reported on at the New Zealand IUGG Meetings and although it operated temporarily, a malfunction caused it to have a much shorter lifetime than the design lifetime. Deficiencies in that system have been corrected. The second sea floor unit has been completed and tested and is ready for installation at the next opportunity at Ocean Station PAPA, which is manned by the Canadian Department of the Environment. The new unit should operate from three to five years producing tsunami data upon acoustical query from the surface ship. A similar unit is being prepared for deployment under a small lightweight buoy system.

3. "A Low Cost Portable Tsunami Wave Gage," by H. G. Loomis.

A long standing need for a simple, inexpensive, portable tsunami wave gage can be met in several ways by making use of a new series of solid state pressure transducers put out by National Semiconductor. This report describes a wave gage made with the first such available transducer, model LX1600A, an absolute pressure transducer with a range of 0 to 2 atmospheres. Now, a whole series of such transducers are available in different pressure ranges, as differential transducers and as gage transducers. The principles of using any of these are similar to those described here for the LX1600A. The unit has a maximum dimension of about 2 cm. and costs about $70 (U. S.). The transducer unit contains a solid-state gage bridge along with suitable integrated circuit amplifiers. The temperature dependence is no worse than ± 2 mV/^{o} F and even this could be corrected for. The linearity is $\pm 1/2\%$ of full scale voltage.

IUGG-IOC MEETING

Arrangements are being made for a supplementary session on tsunamis to be held at the time of the IOC Meeting in Grenoble, France, during September 1975. Professor S. L. Soloviev, Chairman of the Tsunami Committee of the IOC will be directing the organization of that meeting. The Grenoble Meeting will differ in form, markedly, from the Tsunami Workshop which will be held under the sponsorship of the National Science Foundation. Formal papers will be presented in contrast to the more informal discussions of the Workshop.

IOC CIRCULAR LETTER NO. 473

This Circular Letter with reference to SC/91/89L/1 to the Member States of the International Co-ordination Group for the Tsunami Warning System in the Pacific concerned the following subject items:

Item 1. Nomination of candidates for Associate Directorship of the International Tsunami Information Center.

Item 2. Revised Functions of the International Tsunami Information Center.

Item 2, ITIC Functions and IOC Resolution EC-IV.6, were reported in ITIC Newsletter, Volume VII, Number 2, August 1974, and will not be repeated here. However, attention is drawn to the newly established post of Associate Director of the International Tsunami Information Center, Hawaii. Addressees are hereby invited to nominate candidates for this newly established post. Nominations are to be sent to Secretary, IOC, by 31 October 1974, bearing in mind that the salary and cost of living allowances for the incumbent of this new post will have to be paid for by the government of his mother country.

In accordance with the penultimate paragraph of the above resolution, the selection of a suitable incumbent for the post will be determined with the assistance of the Chairman, ITSU, and the Secretary, IOC.

IOC CIRCULAR LETTER NO. 455

With reference to SC/91/89L/2 Circular Letter No. 455 dated 12 April 1974, the Permanent Delegate of Japan to UNESCO has informed ITIC as follows:

1. With respect to paragraph 9 of IOC/ITSU-IV/3, the Government of Japan has nominated the following person as its national contact:

Dr. Shigeji SUYEHIRO
Head, Seismological Division
Observation Department
Japan Meteorological Agency
1-3-4, Ote-machi, Chiyoda-ku, Tokyo

2. With respect to Recommendation 2, in Annex II to IOC/ITSU-IV/3, the Government of Japan proposes "Chichi Jima" instead of Iwo Jima, listed under "Tide Stations-First Priority," and Minamitorishima, listed under "Seismograph Stations-Second Category." Chichi Jima

should be classified as a third category station. Seismological observations have been conducted since July 1972 and tide observations are scheduled to start in April 1975 at this station.

TSUNAMI INVESTIGATIONS -- AUGUST-SEPTEMBER 1974

The Tsunami Warning System at the Honolulu Observatory investigated several large earthquakes and one possible tsunamigenic earthquake which is listed below. No Pacific-wide tsunami had been generated.

Date and Origin Time (U.T.)	Epicenter	Depth	Magnitude	Region	Comments
August ~~20~~ 18 10-44-14.7	38.1S 73.5W	Normal	7.0	Arauco Province, Chile	No evidence of tsunami

HONOLULU OBSERVATORY

Several improvements, listed below, are currently in progress at the Honolulu Observatory.

1. Computer Automation

In April 1974, a computer terminal was installed at the Honolulu Observatory and was connected to a commercial time-shared mini-computer located approximately twenty-five miles from HO. This initial terminal-computer is intended as a feasibility study and the beginning of computer processing for the Tsunami Warning System. At this time, the automation involves message composition. The communication messages currently being automated are the seismic, tide, watch, warning and press releases.

The result of this study is to determine the desirable automation equipment and the extent to which automation is feasible within the Tsunami Warning System.

2. Uninterruptable Power Supply

A 15-KW Onan generator has been purchased and will replace the existing 5-KW generator as a back-up power supply for the Honolulu Observatory. The Onan generator, along with a battery bank and inverter, will be an uninterruptable power source. It has an automatic switching feature which, in the event of a power failure, will automatically furnish power to the equipment and facilities that are necessary for the Tsunami Warning System. The installation is expected to be completed within the very near future.

3. Hawaiian Regional Net

The Hawaiian Regional Net has been in active development during the past several months. This net consists of both seismic and tide sensors. The seismic instruments will transmit data from the islands of Hawaii, Maui and Oahu and tide data will be transmitted from the Western and Southern shores of the island of Hawaii. The real-time data, collected by these sensors, will be telemetered by radio and landlines to the Honolulu Observatory. The net is expected to be operational about December of 1974. The locations of the new net stations are shown below: